

If, then, the question be asked, "What lies in front of the endostyle?" the immediate response is, "In both cases the proboscis-cavity."

I accordingly submit the following table of homologies:—

- (a.) Proboscis-cavity of Ascidiants = Proboscis-cavity and praoral pit of *Amphioxus*.
- (b.) Endostyle of Ascidiants = Endostyle of *Amphioxus*.
- (c.) Mouth of Ascidiants = Mouth of *Amphioxus*.
- (d.) First pair of gill-slits of Ascidiants, in the improved sense of the term. = First pair of gill-slits of *Amphioxus*.

The homology of the club-shaped gland of *Amphioxus* with the intestine of Ascidiants, as suggested by van Beneden and Julin, would seem, therefore, to be quite out of the question.

It need hardly be pointed out that, if the homologies which I have advanced are really correct, then the relations between *Amphioxus* and the Ascidiants become much less strained than they were on the views previously entertained.

I intend shortly to discuss the whole subject more elaborately in the pages of the 'Quarterly Journal of Microscopical Science.'

VI. "The Human Sacrum." By A. M. PATERSON, M.D., Professor of Anatomy in University College, Dundee, St. Andrews University. Communicated by Professor D. J. CUNNINGHAM, D.Sc., F.R.S. Received April 18, 1892.

(Abstract.)

Owing to the now classical investigations of Gegenbaur and Frenkel, and the more recent researches of other observers, the several homologies of the vertebral column are distinctly understood. The specific or individual differences in the correlation of one region of the column to another can be adequately explained on the assumption of a suppression or excessive development of the potential costal element of the vertebral segment. This costal element may be metamorphosed in different ways to suit the needs of the animal economy, and the variations in individual cases affect the segments at the ends of a series where the vertebrae of one region possess characters resembling those of a neighbouring region. This hypothesis renders intelligible, not only the existence of cervical ribs, but also correlated variations of the thoracico-lumbar region, and abnormalities of the sacrum, differences in the number of bones, as well as asymmetry.

During recent years this aspect of the subject and numerous

examples of abnormalities in the arrangement of the vertebral column have been carefully scrutinised in four important monographs. Rosenberg's memoir has excited the most attention, as he has formulated the theory of a phylogenetic shortening of the human vertebral column from behind forwards. He relies for his conclusions upon the examination of abnormalities of the vertebral column of man and the higher apes, and the statement of Kölliker, that the ilium in the process of development at first articulates with hinder segments, and gradually shifts forwards along the vertebræ to be connected with segments placed more anteriorly. Thus Rosenberg regards a human vertebral column with an increased number of præsacral vertebræ as an "ancestral" form : a column with a diminution in the number of præsacral segments as a "future" form, representing a more recent phylogenetic process. Topinard has recorded a number of observations on vertebral abnormalities. He considers that anomalies in the thoracic and lumbar regions may be due to excess, default, or compensatory variations ; that the anomalies of the sacrum are always compensatory, depending partly upon the relation of the ilium to the vertebral column, and partly upon the atrophy and fusion of the caudal vertebræ. He thus gives a qualified support to the notion of intercalation and excalation of vertebræ, as far as the thoracic and lumbar vertebræ are concerned. Regalia and Holl both reject Rosenberg's "atavistic" hypothesis as inadequate. Regalia regards thoracico-lumbar variations as caused by correlated variations in the position and proportions of the thoracic and abdominal viscera ; and agrees with previous authors that lumbo-sacral and sacro-caudal abnormalities are due to alterations in the position of the ilium in relation to the vertebral column. Holl, from embryological investigations, considers that the sacrum, once formed, undergoes no alterations, and that the 25th vertebral segment is, as a rule, the first sacral vertebra from the earliest time. He also asserts that the same segment (*v. fulcralis*) has in the great majority of cases in the adult the main attachment of the ilium. He looks upon variations at the cephalic end of the sacrum as caused by changes in the position of the ilium ; variations at the caudal end, as associated with fusion of the coccyx.

The present memoir deals with the characteristics of the human sacrum, its form and anomalies, its correlation to other regions of the vertebral column in man and other mammals, its relation to the spinal nervous system, and its ossification, especially in relation to that aspect of the question brought into prominence by Rosenberg's hypothesis. The sacral index and the sacral curve are also dealt with.

The investigations have been made in a series of 265 adult sacra and numerous foetal vertebral columns. Of the adult sacra, 36

belonged to spines absolutely complete, and 96 to spines complete except for a deficiency of the coccyx. The material has been obtained from many sources : and I am specially indebted to Professor D. J. Cunningham, of Dublin, for the use of a large number of specimens, and notes and drawings of observations made by him on the subject.

The conclusions arrived at are as under :—

1. The examination of a large series of vertebral columns compels one to discard as inadequate the theory of "intercalation" and "excalation" to account for the variations in the number of vertebrae in the several regions. The hypothesis of inherent variability, of shifting of one region at the expense of another, fully explains the cases of individual variation. The changes met with may be regarded as produced, not by the sudden (and anomalous) interposition or loss of a vertebral segment, but by a conversion of the segments of one region into those of another and contiguous region.

2. (a.) There is a marked tendency on the part of the first sacral vertebra to be liberated from the rest of the sacrum. It retains its individuality more clearly than the other vertebrae, and frequently approximates in type to the lumbar series.

(b.) The surface for articulation with the ilium, while usually placed on the first two, and a part of the third, sacral vertebrae, varies considerably in position. The surface may be shifted backwards or forwards ; and the tendency is more marked towards a shifting in the caudal than the cephalic direction.

(c.) The surface for attachment of the sacro-iliac ligaments is generally subdivided into two or three depressions, of which that on the first sacral vertebra is, in the great majority of cases, the largest and deepest. The inference from this fact is that the first sacral vertebra has usually the greatest responsibility in supporting the ilium.

(d.) In the vast majority of cases there are five constituent bones in the sacrum. Increase to six is much more common than diminution to four ; and increase by addition at the caudal end is apparently much more common than by addition at the cephalic end.

(e.) Asymmetry of the sacrum occurs frequently (8·3 per cent.). It occurs in two forms : as either a sacro-coccygeal or a lumbo-sacral vertebra ; and in two ways, by diminution or addition at either end in the number of component bones. A sacro-coccygeal vertebra is more frequent than a lumbo-sacral ; and asymmetry with addition is more common than asymmetry with diminution in the number of bones forming the sacrum.

(f.) The examples of correlated variations of the several regions of the vertebral column indicate a greater tendency towards increase than diminution in the total number of bones. Increase is more common than diminution in the number of bones in the præsacral, sacral, and

caudal regions respectively. Increase in the sacral region is more common by abstraction from the caudal than from the lumbar series. Liberation of the first sacral vertebra is more common than assimilation of the fifth lumbar vertebra; and assimilation of the first caudal vertebra is more common than liberation of the fifth sacral. With regard to the sacrum particularly, there is found to be a certain limited and inherent variability in the position of the ilium, causing it to be shifted backwards or forwards in relation to the vertebral axis, and more frequently backwards than forwards. There appear to be three separate influences acting upon the sacrum, and producing the differences in number of bones, correlated variations, and asymmetry:—(1) fusion of the first caudal vertebra; (2) liberation of the first sacral vertebra, by a backward shifting of the ilium, along the vertebral axis; and (3) fusion of the last lumbar vertebra with the sacrum, by a forward shifting of the iliac attachment. The first influence is most commonly seen, and may be exerted alone or along with the second. The second and third influences are opposed to one another. The former is more frequent than the latter, producing an additional lumbar, or a lumbo-sacral vertebra; the latter gives rise to a diminution in the number of free lumbar vertebrae, and may be accompanied by the conversion of the last sacral into a sacro-caudal or caudal vertebra.

(g.) A study of the ossification of the vertebral column leads to similar conclusions, and indicates the existence of inherent variability in the several regions, and a greater tendency to elongation than contraction of the vertebral column as a whole. The process of ossification also shows that the ala of the first sacral vertebra (25th spinal segment) is usually the first to ossify; which vertebra may therefore be regarded as the one primarily responsible for the attachment of the ilium. The exceptional cases occur in sacra showing correlated variations or asymmetry, and indicate a greater tendency on the part of the ilium to be shifted backwards than forwards.

(h.) The evidence derived from a consideration of the vertebral column in other vertebrates is unsatisfactory. The human spine holds, with regard to correlated variations, a position intermediate between anthropoid apes (in which they are very frequent) and quadrupeds generally (in which they are rarely present); while asymmetry, especially of the sacrum, may be looked upon as an essentially human characteristic.

(i.) The examination of the correlation of the spinal nerves and limb-plexuses with the vertebral segments shows both specific and individual differences in this respect. The individual differences may be classified under three types:—(1) a variation in the arrangement of the nerves without any concomitant variation in the vertebral column; (2) a variation in the vertebral column without any con-

comitant variation in the nerves; and (3) a coincident variation in both nervous system and vertebral column. These varying relations of the nervous system to the vertebral column diminish the value of the spinal nerves in the determination of the serial homologies of the vertebral segments. Further information as to the relative frequency of abnormalities in the disposition of the spinal nerves in the limb-plexuses and the relative frequency of the various modes of correlation of the spinal nerves and vertebral column is required before adequate conclusions can be formulated on this point. One can only indicate the striking fact that all the examples of variation in the arrangement of the spinal nerves in man and anthropoids are examples pointing to an extension *backwards* of the limb-plexuses, by the entrance into them of post-axially placed nerves. The evidence of the nervous system favours, therefore, the view rather of extension backwards than forwards of the limbs in relation to the vertebral column, as far as present knowledge enables us to judge.

When all these points are considered together—the cases of liberation of the first sacral vertebra, the mode of articulation of the ilium; the form of the ligamentous surface and the number of bones forming the sacrum; the correlated variations; the examples of asymmetry; and the evidence derived from a consideration of the vertebral column in other vertebrates, of the correlation of the nervous system and the vertebral column, and of the development and ossification of the vertebral column in man—the array of facts presented does not afford much support to the theory of a phylogenetic shortening of the vertebral column advocated by Rosenberg. The conclusion to which these facts lead is rather that there is in the human vertebral column a certain limited variability in the correlation of the several parts. The actual variations met with may be in the direction of elongation or abbreviation of a particular region, and more often produce elongation than contraction of the præsacral region. There is no evidence to show that any definite process of either shortening or lengthening of the vertebral column is going on phylogenetically. The variations found are apparently individual peculiarities; which, however, taken together, indicate a tendency to elongation rather than contraction of the præsacral region.

At the same time, these investigations give support to the view put forward by Rosenberg and Topinard, that a process of fusion of the rudimentary caudal vertebrae with the sacrum is going on, in consequence of the immobility of the caudal appendage, and resulting in an increase posteriorly of the number of sacral vertebrae, and a diminution, *pari passu*, in the number of free caudal vertebrae.

3. The sacral index was computed in a large number of cases, including 100 Europeans, 20 Andamanese, 9 Negroes, 10 ancient

Egyptians, 5 Hindoos, 8 Australians, and a small number of examples of several other races. The results obtained were compared with those given by Professor Sir William Turner in his monograph on the Human Crania and Bones of the Skeleton, collected during the voyage of H.M.S. "Challenger."

The mean index calculated from the two series of observations, disregarding sex, is 106·7; of the males alone, 103·5. The human sacrum is thus generally broader than long, as already known; and the female sacrum is relatively broader than the male.

The races dealt with may be divided into three classes:—(a.) Those distinctly *dolichohieric*, with a sacral index below 100, including the Kaffir, Hottentot, and Bushman. (b.) Those which may be called *sub-platyhieric*, with an index between 100 and 106, including the Andamanese, Australian, Chinese, Tasmanian, and Negro races. (c.) Those which are clearly *platyhieric*, with an index over 106, including American, ancient Egyptian, Melanesian and Polynesian, Hindoo, European, and other races examined.

4. The sacral curvature was examined in 236 cases, of which 82 were males, 38 females, and the rest of unknown sex. The curve is generally deepest opposite the third sacral vertebra, and is more deeply curved below than above that point. It is not an equal and uniform curve, but is flattened above, and possesses a more pronounced curvature below the third sacral vertebra. This occurs in both sexes and in all races. A promontory between the first and second sacral vertebrae occurs frequently, in the majority of cases in association with an additional sacral vertebra, and more often in the male than in the female.

The female sacrum is more frequently curved more deeply in the upper part of the bone than the male sacrum.

The actual depth of the curve, that is, the amount of curvature, is greater in the male than in the female, irrespective of the absolute size of the sacrum. The amount of curvature is greatest in the European races, and, apparently, greater in the European and Mongolian races than in the Negro and Polynesians.

The Society adjourned over Ascension Day to Thursday, June 2.

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Transactions.

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